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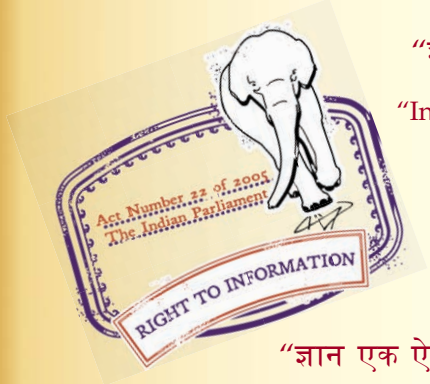

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भाग 2 सदृयता परीक्षण

(पहला पुनरीक्षण)

Indian Standard

SHUNT CAPACITORS FOR a.c. POWER SYSTEMS HAVING A RATED VOLTAGE ABOVE 1 000 V

PART 2 ENDURANCE TESTING

(First Revision)

ICS 29.240.99;31.060.70

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 2002

Price Group 5

NATIONAL FOREWORD

This Indian Standard (Part 2) (First Revision) which is identical with IEC 60871-2 (1999) 'Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V — Part 2 : Endurance testing' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Power Capacitors Sectional Committee and approval of the Electrotechnical Division Council.

This standard (Part 2) was first published in 1994. The first revision has been contemplated in order to align with the latest publication issued by International Electrotechnical Commission.

The text of the IEC Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker

CROSS REFERENCES

In this adopted standard, references appear to certain International Standards for which Indian Standard also exist. The corresponding Indian Standard which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60871-1 (1997) Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V — Part 1 : General performance, testing and rating — Safety requirements — Guide for installation and operation	IS 13925 (Part 1) : 1998 Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V : Part 1 General performance, testing and rating — Safety requirements — Guide for installation and operation (Superseding IS 2834 : 1986)	Equivalent
IEC 60996 : 1989 Method for verifying accuracy of tan delta measurements applicable to capacitors	IS 13203 : 1991 Method for verifying accuracy of tan delta measurements	do

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Only the English text of the International Standard has been retained while adopting it in this Indian Standard.

Indian Standard

SHUNT CAPACITORS FOR a.c. POWER SYSTEMS HAVING A RATED VOLTAGE ABOVE 1 000 V

PART 2 ENDURANCE TESTING

(First Revision)

1.1 Scope and object

This technical specification applies to capacitors according to IEC 60871-1 and gives the requirements for overvoltage cycling and ageing tests of these capacitors.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60871. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60871 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60871-1:1997, *Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*

IEC 60996:1989, *Method for verifying accuracy of tan delta measurements applicable to capacitors*

1.3 Definitions

For the purpose of this technical specification, the following definitions apply in addition to those given in IEC 60871-1:

1.3.1
test (capacitor) unit
one of the units to be manufactured or a special unit which, with respect to the properties to be checked by the overvoltage cycling and ageing tests, is equivalent to the units to be manufactured. The design may be different for the overvoltage cycling and ageing test units. (The restrictions on test unit design are detailed in annex B.)

1.3.2
comparable element design
a range of construction elements that will be comparable in performance, under the test procedure, with elements of the units to be manufactured (see annex B for detailed design limits)

1.3.3
inter-element insulation
the insulation between two series-connected elements, consisting of:

- the outer turns of the insulation layers around the electrodes in an element, or
- a separate insulation layer placed between the two elements. This separate insulation layer may protrude outside the width and (or) length dimension(s) of the flattened element (see annex C).

2 Quality requirements and tests

2.1 Test requirements

2.1.1 Classification of tests

The overvoltage cycling test is a type test carried out in order to ascertain that repeated overvoltage cycles, at temperatures ranging from the lowest rated temperature to room temperature, do not cause a dielectric breakdown.

The ageing test is a type test carried out in order to ascertain that the progression of deterioration resulting from increased voltage stress at elevated temperature does not cause untimely failure of the dielectric.

Both of these tests shall be carried out as type tests by the manufacturer for a particular dielectric system (not for each particular capacitor rating, as the type test results are applicable to a wide range of capacitor ratings within the limits defined in annex B). The purchaser shall, on request, be supplied with a certificate detailing the results of such tests.

2.1.2 Endurance test and requirements

The overvoltage cycling and ageing tests shall be carried out in the sequence given below. One group of test units shall be subjected to the overvoltage cycling test and another group to the ageing test, or the manufacturer can subject one group of units to both tests.

The applied test voltage shall have a frequency of 50 Hz or 60 Hz, except for the test according to 2.1.2.1 where a d.c. voltage can be used according to 9.2 of IEC 60871-1.

2.1.2.1 Routine test

The test unit shall be subjected to the routine voltage test between the terminals (see IEC 60871-1, clause 9) with an amplitude such that the correct test voltage is obtained across each element.

2.1.2.2 Conditioning of the units before the test

The test unit shall be subjected to a voltage of not less than 1,1 U_N at an ambient temperature of not less than +10 °C for not less than 16 h.

NOTE The conditioning is carried out to stabilize the dielectric properties of the test units.

2.1.2.3 Initial capacitance and dielectric loss measurements

The test unit shall be placed for at least 12 h in the unenergized state in a chamber with forced air circulation having a temperature selected from the range +60 °C to +75 °C with a permitted variation of ±2 °C.

The unit, at the same ambient temperature, shall then be subjected to U_N. The capacitance and the dielectric losses shall be measured within 4,5 min to 5,5 min after the voltage application.

NOTE 1 The measuring procedures according to 7.1 and 8.1 of IEC 60871-1 should be followed, except for the temperature and measuring time requirements which are according to this subclause.

NOTE 2 Instead of performing the test at the same ambient temperature the test unit may be thermally insulated in order to avoid a temperature decrease in the test unit before the measurement has been completed.

2.1.2.4 Test voltages

For capacitors which are exposed to higher overvoltages, transients, etc. (e.g. see note 5 in 9.1 of IEC 60871-1, and 31.1 of IEC 60871-1), the amplitude of the applied test voltages in the overvoltage cycling test (see 2.1.3 and annex A) shall be increased accordingly.

2.1.3 Overvoltage cycling test

2.1.3.1 Test method

The unit shall be placed for at least 12 h in the unenergized state in a chamber with forced air circulation having a temperature not exceeding the lower limit of the temperature category (see 4.1 of IEC 60871-1).

The test unit shall then be placed in still air at an ambient temperature of +15 °C to +35 °C.

Within 5 min after being taken out of the ventilated chamber, the test unit shall be subjected to 1,1 U_N. If the 5 min limit cannot be achieved before voltage application, the test unit shall be thermally insulated in order to avoid undue heating. Within 5 min after the voltage application, an overvoltage of 2,25 U_N shall be applied without any voltage interruption for a duration of 15 cycles after which the 1,1 times U_N voltage is maintained again without any voltage interruption. After an interval of 1,5 min to 2 min at 1,1 U_N, another equal overvoltage shall be applied and the procedure repeated.

The unit shall be subjected daily to a total of 130 to 170 overvoltage periods, each of 15 cycles duration.

The unit shall then immediately be placed in the ventilated cooled chamber again for at least 12 h in the unenergized state and the test shall continue each day until the unit has been subjected to a total of 850 overvoltage periods of 15 cycles duration (total of 12 750 overvoltage cycles).

NOTE 1 Detailed requirements regarding the overvoltage shape and the tolerances are given in annex A.

NOTE 2 The test should be carried out on consecutive days. Interruptions are permitted, provided that the test unit remains unenergized in the cooled chamber during the whole interruption period.

2.1.3.2 Final capacitance and dielectric loss measurements

The measurements according to 2.1.2.3 shall be repeated at the same temperature, voltage and frequency within two days of completing the tests in 2.1.3.1.

2.1.3.3 Acceptance criteria

No breakdown shall occur when two units have been tested, or alternatively one breakdown is accepted when three units have been tested.

The capacitance measurements performed in 2.1.2.3 and 2.1.3.2 shall differ by less than an amount corresponding to either breakdown of an element or operation of an internal fuse.

2.1.4 Ageing test

2.1.4.1 Test method

The temperature of the dielectric during the ageing test shall be at least equal to the higher of the following temperatures:

a) 60 °C;

b) the sum of the highest mean temperature in 24 h (see IEC 60871-1, table 1) and the dielectric temperature rise attained at the end of the thermal stability test for the unit to be manufactured (see IEC 60871-1, clause 13).

NOTE The dielectric temperature may be measured with thermocouples or estimated from the capacitance measurement at the end of the thermal stability test using the curve of capacitance versus temperature, or can be estimated from previously established relationships between internal and external temperatures such as by use of resistive dummy capacitors described in IEC 60996.

During this test, the test unit shall be placed in a chamber with ambient temperature adjusted to achieve the required dielectric temperature. The ambient temperature shall be held constant with a tolerance of –2 °C to +5 °C. Prior to energization, the test units shall be stabilized in this ambient for 12 h. Due to the length of this test, voltage interruptions are allowed. During these interruptions, the units shall remain in the controlled ambient. If power is lost to the chamber, the ambient temperature shall be reattained for 12 h prior to re-energization of the units.

The testing time shall depend on the test voltage. Either one of the following test conditions shall be used:

Test voltage	Duration h
1,25 U_N	3 000
1,40 U_N	1 000

2.1.4.2 Final capacitance and dielectric loss measurements

The measurements according to 2.1.2.3 shall be repeated at the same temperature, voltage and frequency within two days of completing the tests in 2.1.4.1.

2.1.4.3 Acceptance criteria

No breakdown shall occur when two units have been tested, or alternatively one breakdown is accepted when three units have been tested.

The capacitance measurements performed in 2.1.2.3 and 2.1.4.2 shall differ by less than an amount corresponding to either breakdown of an element or operation of an internal fuse.

2.1.5 Validity of test

The endurance test is a test on the elements (their dielectric design and composition), and on the manufacturing process of these elements when assembled into a capacitor unit.

2.1.5.1 Unit design variations

Each endurance test will also cover other capacitor designs, which are allowed to differ from the tested design within the limits stated in annex B.

2.1.5.2 Service condition variations

Each endurance test will also cover other service conditions according to the following items:

- units having a lowest temperature category higher than that of the overvoltage cycling test unit;
- units having a highest temperature category lower than that of the ageing test unit;
- a test performed at 50 Hz is also applicable for 60 Hz (and lower frequency) units and vice versa.

Annex A
(normative)

Waveform of overvoltage

The test voltage shall have a frequency of 50 Hz or 60 Hz.

The overvoltage shall be applied without any interruption of the steady voltage of 1,05 U_N to 1,15 U_N.

The amplitude limits for the constant voltage and overvoltage are given in figure A.1.

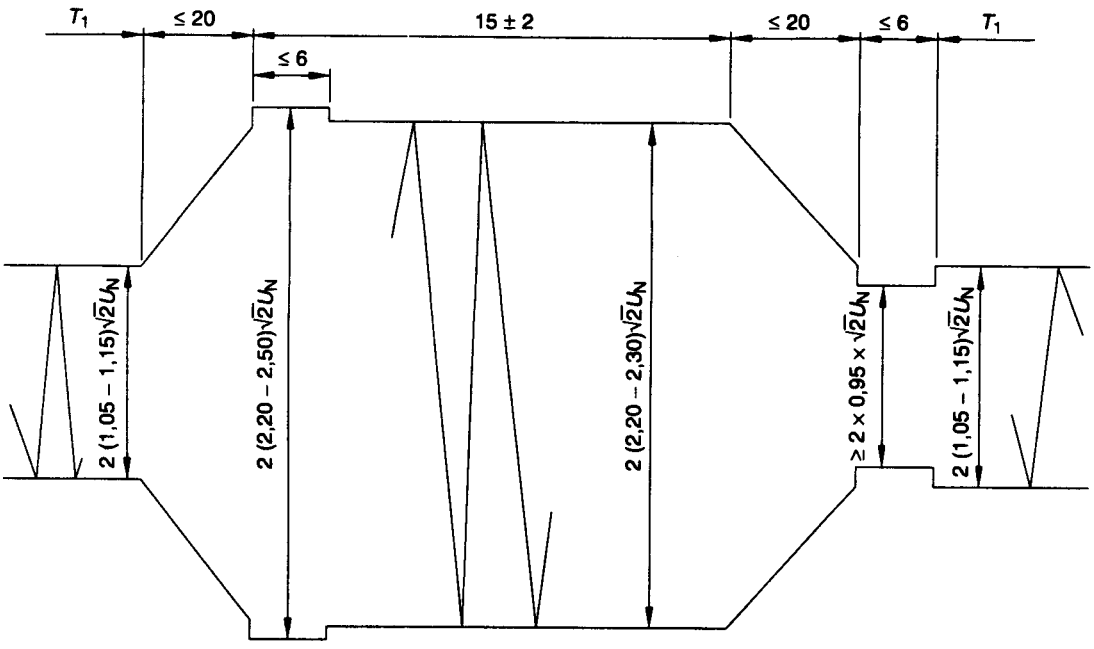

Figure A. 1 — Time and amplitude limits for an overvoltage period

Times, other than T_1, are expressed in numbers of cycles of the test frequency.

T_1 is the interval of 1,5 min to 2 min between two consecutive overvoltage periods.

Annex B
(normative)

Requirements regarding comparable element design and test unit design

B.1 Test element design criteria

A tested element design is considered to be comparable with respect to the elements in the units to be manufactured if the following requirements are fulfilled:

a) the tested element shall have the same or an inferior number of layers of solid materials in the dielectric and be impregnated with the same liquid.

   For the overvoltage cycling test, both the rated voltage and the electrical stress shall be equal or higher.

   For the ageing test, the dielectric shall be within 70 % to 130 % of the thickness and be rated at equal or higher electrical stress.

   When a dielectric contains both film and paper, the stress value to be used in this comparison is the stress across each of the solid materials, calculated using the thickness of only the solid materials and their respective permittivities;

b) the dielectric composition of the solid materials shall be the same, for example all-film or all-paper or film-paper-film, etc.;

c) solid and liquid dielectric materials shall satisfy the same manufacturer's specifications;

d) the aluminum-foil design shall be the same:
   - same manufacturer's specification;
   - thickness within ±20 %;
   - extended or non-extended foil edges;
   - folded foil at the edges and (or) cut ends if it is a feature of the design;
   - less or equal free margin;

e) element connections shall be of the same type, for example tabs, soldering, etc.;

f) the element width (active foil width) is allowed to vary within 50 % to 400 % and the element length (active foil length) is allowed to vary within 30 % to 300 % (see annex C).

B.2 Test unit design

A test unit is considered to be comparable to the units to be manufactured if the following requirements are satisfied :

a) elements meeting the requirements of clause B.1 shall be similarly assembled, have equal or thinner inter-element insulation, be equally pressed within the manufacturing tolerance, etc., as compared with the units to be manufactured;

b) at least four of these elements shall be connected to give not less than 30 kvar output at rated voltage (50 Hz). All connected elements shall be placed adjacent to each other. For the overvoltage cycling test unit, at least one inter-element insulation shall be assembled in such a way that, during the test, it is exposed to the voltage difference occurring between two series-connected elements.

NOTE The connected elements may be series and parallel-connected in any way to match the test equipment. For the ageing test unit, all elements may be connected in parallel.

c) the connections outside the tested elements may be enlarged in order to handle the increased currents due, for example, to a number of elements in parallel;

d) the insulation to the container shall be of the same thickness or thicker;

NOTE This requirement is intended to ensure that the drying and impregnation conditions are equal to those of the units to be produced. The electrical withstand requirements of the insulation to container are taken care of by the tests according to clauses 10, 15 and 16 of IEC 60871-1.

e) a container to the manufacturer's standard design shall be used within the following dimensional limits as compared to the unit to be manufactured:

- depth of container: 50 % to 200 %;
- height of container: 50 % to 400 %;
- width of container: 50 % to 200 %.

NOTE These ranges in container dimensions are necessary to allow for the variation in element sizes.

The container material shall be identical, but the painting may be different.

The bushing design and number of bushings may be adjusted in order to match the test voltage and/or test currents;

f) the drying and impregnation process shall be identical with the normal production process;

g) the test unit shall in all other respects have the same components, such as type of discharge resistors and internal fuses, and follow the same manufacturing procedure as the units to be produced.

Annex C
(informative)

Definition of element and capacitor container dimensions

C.1 Flattened pressed element

The element has been pressed flat in the height direction.

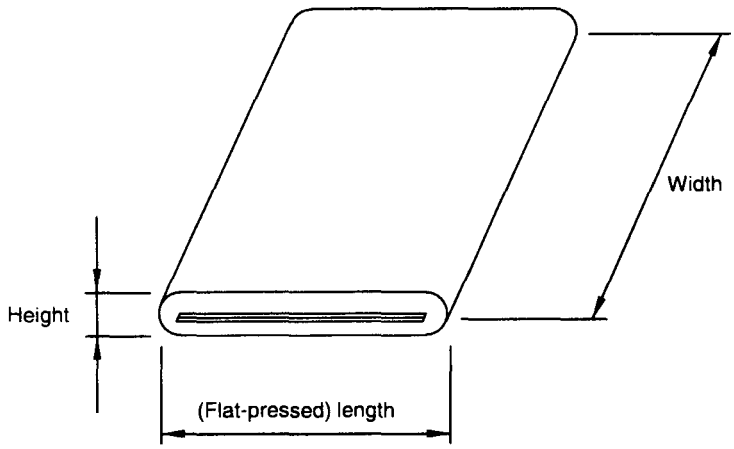

Figure C.1 – Flattened pressed element

Element or (active) foil length is obtained by unwinding the element in the length direction.

C.2 Capacitor container

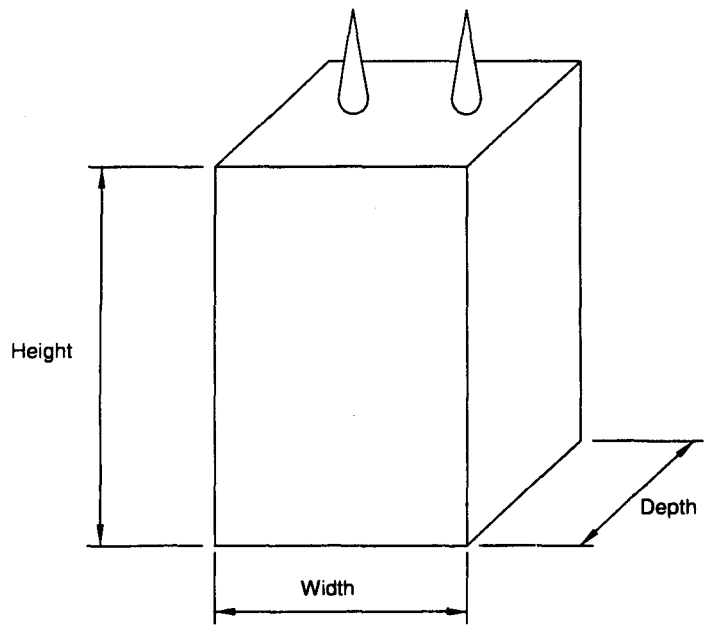

Figure C.2 – Capacitor container

Height is always determined from the side on which the bushings are fitted to the opposite side. Normally the length dimension of the flattened element corresponds to the container depth dimension. Depending on the design, the element width direction may correspond to either the container height or the container width dimension.

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This Indian Standard has been developed from Doc : No. ET 39 (5180).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at New India Printing Press, Khurja, India